Unit 4 Review Answers

Student Textbook pages 328-331

Answers to Understanding Concepts Questions

1. (a) The coefficients in a balanced chemical equation represent the number of atoms, molecules, or ions participating in the reaction.

(b) The coefficients also represent the number of moles of a specific atom, molecule, or ion participating in the reaction.

2. The mass of products and the mass of reactants in a balanced equation are equal. Since the same numbers of atoms, molecules, or ions remain the same so must the masses of these substances.

3. (a) $H_2(g) + CuO(s) \rightarrow Cu(s) + H_2O(g)$ single replacement

(b) $16Ag(s) + S_8(s) \rightarrow 8Ag_2S(s)$ formation

(c) $C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$ combustion

(d) $2MgO(s) \rightarrow 2Mg(s) + O_2(g)$ decomposition

(e) $Al_2(SO_4)_3(aq) + 3K_2CrO_4(aq) \rightarrow 3K_2SO_4(aq) + Al_2(CrO_4)_3(s)$ double replacement

4. (a) $2CH_3OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$ combustion

(b) $P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$ formation

(c) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ decomposition

(d) $3Sr(NO_3)_2(aq) + 2K_3PO_4(aq) \rightarrow Sr_3(PO_4)_2(s) + 6KNO_3(aq)$ double replacement

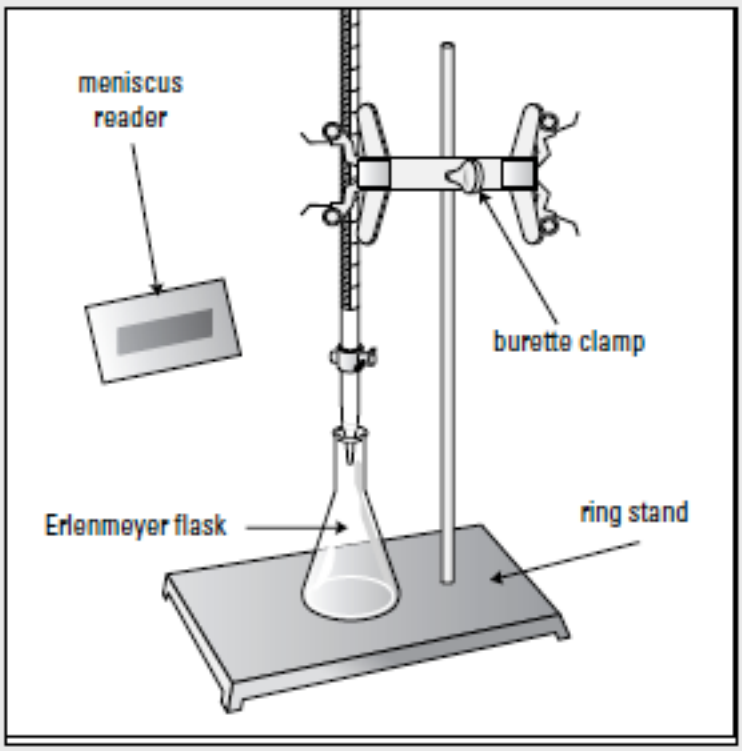
(e) $2Li_3N(s) \rightarrow 6Li(s) + N_2(g)$ decomposition

(f) $Ca(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(s) + H_2(g)$ single replacement

5. **(a)** high solubility
   (b) high solubility
   (c) high solubility
   (d) low solubility
   (e) low solubility
6. **(a)** $2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$
   (b) $Cd(s) + Pb(NO_3)_2(aq) \rightarrow Pb(s) + Cd(NO_3)_2(aq)$
   (c) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
   (d) $Sr(OH)_2(aq) + H_2SO_3(aq) \rightarrow SrSO_3(s) + 2H_2O(\ell)$
   (e) $8HgS(s) \rightarrow 8Hg(\ell) + S_8(s)$
7. $Al_2(SO_4)_3(aq) \rightarrow 2Al^{3+}(aq) + 3SO_4^{2-}(aq)$
8. **(a)** $Pb(NO_3)_2(aq) + 2NaBr(aq) \rightarrow PbBr_2(s) + 2NaNO_3(aq$
   (b) $Pb^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + 2Br^-(aq) \rightarrow PbBr_2(s) + 2NO_3^-(aq) + 2Na^+(aq)$
   (c) The spectator ions are $NO_3^-(aq)$ and $Na^+(aq)$.
   (d) $Pb^{2+}(aq) + 2Br^-(aq) \rightarrow PbBr_2(s)$
9. $2Ag^+(aq) + CrO_4^{2-}(aq) \rightarrow Ag_2CrO_4(s)$
10. $2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(\ell)$

    Since the number of moles of hydrochloric acid and barium hydroxide are equal, the hydrochloric acid will be the limiting reactant and the barium hydroxide will be in excess. In order to be in stoichiometric amounts, twice as many moles of acid would need to be present to completely react with the base.
11. **(a)** ring stand, burette clamp, burette, burette funnel, beakers, Erlenmeyer flasks, volumetric pipette, meniscus reader pipette bulb

(b)



12. The equivalence point of a reaction occurs when the reactants are present in stoichiometric amounts. The endpoint occurs when the indicator changes colour. A satisfactory endpoint occurs with the addition of one drop of titrant that drives the pH beyond the equivalence point.

13. A burette should be thoroughly rinsed with de-ionized water, then rinsed with the titrant before filling it with the titrant.

14. A total ionic equation lists all the entities involved in a chemical reaction. A net ionic equation represents only those entities that change during the course of the reaction.

15. A sample equation is as follows.

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(\ell)$

Answers to Applying Concepts Questions

16. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

A total of 200 molecules of hydrogen chloride will be produced. The chlorine gas is in excess and 100 molecules of the gas will remain.

17. $Li_2SO_4(s)$

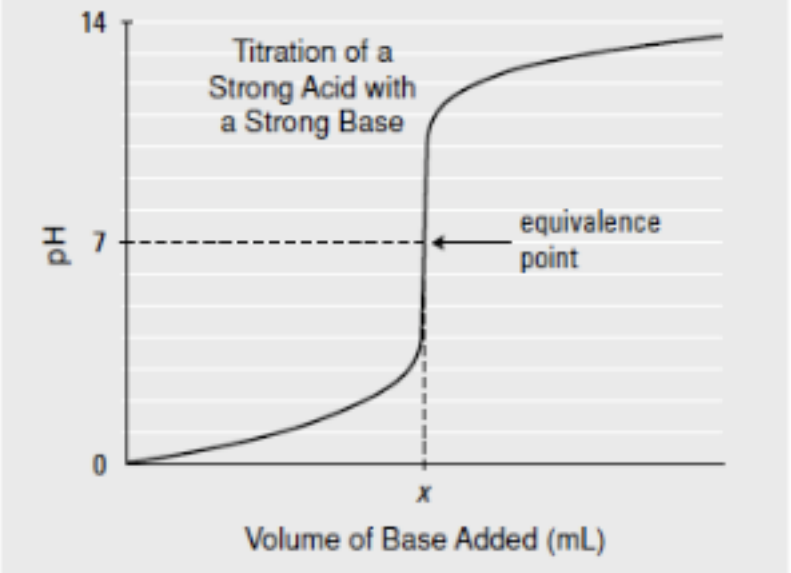
18. Student answers may vary. One such sequence would be $NaCH_3COO(aq)$, $NaCl(aq)$, followed by $Na_2SO_4(aq)$

19. Students' answers will vary. Designs can include titration with hydrochloric acid to determine which antacid neutralizes the most stomach acid or the pH of a sample of acid when the antacid is added. In each case, the dose of the antacid should be controlled. The manipulated variable is the brand of antacid and the responding variable is the volume of acid neutralized/pH of the solution (depending on design).

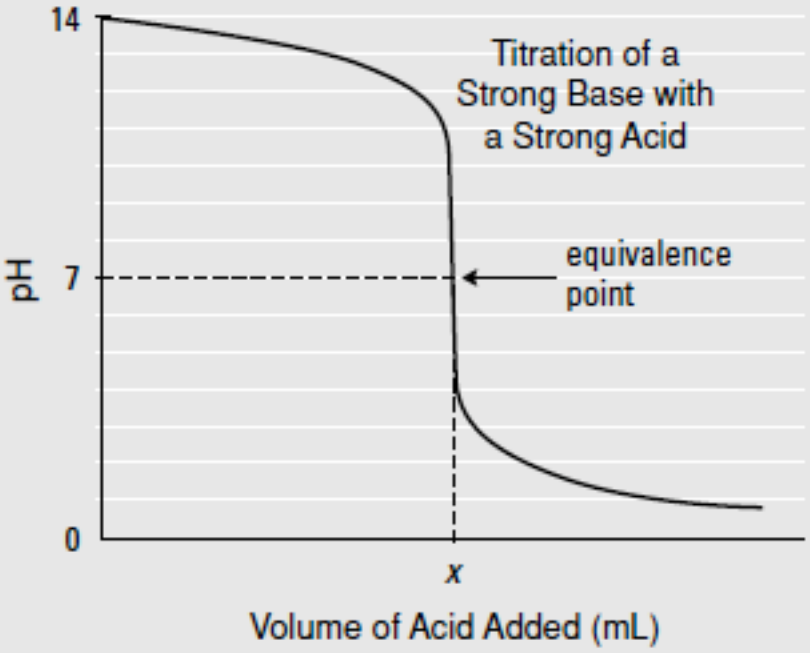
20. $Cu^{2+}(aq) + S^{2-}(aq) \rightarrow CuS(s)$

Copper(II) sulfide is the precipitate.

21. (a) The pH curve begins at a relatively low pH and remains low until a very steep rise near the equivalence point at pH 7. Slightly after the equivalence point, the curve flattens out at a relatively high pH.



(b) The pH curve begins at a relatively high pH and remains high until a very steep drop near the equivalence point at pH 7. After the steep drop, the curve flattens out at a relatively low pH.



These two curves are inverse of each other (if you flip the curve vertically).

22. A diluted sample of the drain cleaner will be titrated with a standardized solution of hydrochloric acid using methyl orange as the indicator.

A sound procedure ought to have:

- between 5 and 10 steps
- steps that are sufficient to obtain the kind of data/information needed to answer the problem
- a good control of variables
- a clean burette and pipette
- a suitable indicator and knowledge of what to observe (the colour change at the endpoint)
- modest sample size (5 mL, 10 mL, 20 mL)
- repetition of the titration for accuracy
- clean-up/disposal considerations

A good exemplar would be:

1. Set up the titration apparatus as demonstrated by your teacher. Rinse the burette with de-ionized water, then with the standardized hydrochloric acid.
2. Fill the burette with the standardized hydrochloric acid.
3. Measure and record the initial burette reading.
4. Use a clean pipette to obtain 10.0 mL of the diluted drain cleaner solution and deliver it to a clean 125 mL Erlenmeyer flask.
5. Add 2–3 drops of methyl orange (or other suitable indicator) to the sample in the flask and note the initial indicator colour.
6. Titrate the diluted drain cleaner sample with the hydrochloric acid until a distinct endpoint is observed (the colour change should be described at this point, in this case the solution changes from yellow to orange or red). Record the final burette reading.
7. Repeat steps 3 to 6 until you have performed three consecutive titrations with differences within a +/– 0.1 mL range.
8. Clean up your laboratory station and dispose of all waste as instructed by your teacher.

Answers to Solving Problems Questions

23. $3H_2SO_4(aq) + Ca_3(PO_4)_2(s) + 6H_2O(\ell) \rightarrow 2H_3PO_4(aq) + 3CaSO_4 \cdot 2H_2O(s)$

$m = 1.00$ kg $\quad m = ?$ Kg

$M = 310.18$ g/mol $\quad M = 172.19$ g/mol

$$m\,CaSO_4 \cdot 2H_2O = 1.00\ kg\ Ca_3(PO_4)_2 \times \frac{1\ \cancel{mol\ Ca_3(PO_4)_2}}{310.18\ g\ \cancel{Ca_3(PO_4)_2}} \times \frac{3\ \cancel{mol\ CaSO_4 \cdot 2H_2O}}{1\ \cancel{mol\ CaSO_4 \cdot 2H_2O}} \times \frac{172.19\ g\ \cancel{CaSO_4 \cdot 2H_2O}}{1\ \cancel{mol\ CaSO_4 \cdot 2H_2O}}$$

$$= 1.67\ kg$$

24. $C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$

$m = ?\ Ig$ $\quad m = 1.1\ Tg$

$M = 30.08\ g/mol$ $\quad M = 28.06\ g/mol$

$$m\,C_2H_4 = 1.1\ Tg\ C_2H_4 \times \frac{1\ \cancel{mol\ C_2H_4}}{28.06\ g\ C_2H_4} \times \frac{1\ \cancel{mol\ C_2H_6}}{1\ \cancel{mol\ C_2H_4}} \times \frac{30.08\ \cancel{g\ C_2H_6}}{1\ \cancel{mol\ C_2H_6}}$$

$$= 1.2\ Tg$$

25. $Pb(s) + Cu(NO_3)_2(aq) \rightarrow Cu(s) + Pb(NO_3)_2(aq)$

$m = 1.0\ g$ $\quad m = ?\ g$

$M = 207.21\ g/mol$ $\quad M = 63.55\ g/mol$

$$m\,Cu = 1.0\ g\ Pb \times \frac{1\ \cancel{mol\ Pb}}{207.21\ g\ Pb} \times \frac{1\ \cancel{mol\ Cu}}{1\ \cancel{mol\ Pb}} \times \frac{63.55\ g\ Cu}{1\ \cancel{mol\ Cu}}$$

$$= 0.31\ g$$

26. $CaCO_3(s) + 2CH_3COOH(aq) \rightarrow Ca(CH_3COO)_2(aq) + CO_2(g) + H_2O(\ell)$

$m = ?\ g$ $\quad m = 12.5\ g$

$M = 100.09\ g/mol$ $\quad M = 60.06\ g/mol$

$$m\,CaCO_3 = 12.5\ g\ \cancel{CH_3COOH} \times \frac{1\ \cancel{mol\ CH_3COOH}}{60.06\ g\ \cancel{CH_3COOH}} \times \frac{1\ \cancel{mol\ CaCO_3}}{2\ \cancel{mol\ CH_3COOH}} \times \frac{100.09\ g\ CaCO_3}{1\ \cancel{mol\ CaCO_3}}$$

$$= 10.4\ g$$

Since 12.5 g of ethanoic acid will react completely with only 10.4 g of calcium carbonate, the lime scale will not be completely removed.

27. (a) $Pb(CH_3COO)_2(aq) + 2NH_4Cl(aq) \rightarrow PbCl_2(s) + 2NH_4CH_3COO(aq)$

(b) $V = 21.0\ mL$ $\quad m = ?\ g$

$c = 0.125\ g/mol$ $\quad M = 278.11\ g/mol$

$$m\,PbCl_2 = 21.0\ \cancel{mL} \times \frac{0.125\ \cancel{mol\ NH_4Cl}}{1\ \cancel{L}} \times \frac{1\ \cancel{mol\ PbCl_2}}{2\ \cancel{mol\ NH_4Cl}} \times \frac{278.11\ g\ PbCl_2}{1\ \cancel{mol\ PbCl_2}}$$

$$= 365\ mg$$

28. $HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(\ell)$

$V = 2.68\ L$ $\quad V = 3.17\ L$ $\quad m = ?\ g$

$c = 2.11\ mol/L$ $\quad c = 2.29\ mol/L$ $\quad M = 74.55\ g/mol$

If the HCl is limiting

$$m\,KCl = 2.68\ \cancel{L} \times \frac{2.11\ \cancel{mol\ HCl}}{1\ \cancel{L}} \times \frac{1\ \cancel{mol\ KCl}}{1\ \cancel{mol\ HCl}} \times \frac{74.55\ g\ KCl}{1\ \cancel{mol\ KCl}}$$

$$= 422\ g$$

If the KOH is limiting

$$m\,\mathrm{KCl} = 3.17\ \mathrm{L} \times \frac{2.29\ \mathrm{mol\ KOH}}{1\ \mathrm{L}} \times \frac{1\ \mathrm{mol\ KCl}}{1\ \mathrm{mol\ KOH}} \times \frac{74.55\ \mathrm{g\ KCl}}{1\ \mathrm{mol\ KCl}}$$

$$= 541\ \mathrm{g}$$

Since HCl(aq) produces the least mass of product, it is the limiting reactant and the mass of KCl(aq) produced will be 422 g.

29. $H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(\ell)$

$V = 25.0\ \mathrm{mL}$ $\quad V = 38.93\ \mathrm{mL}$

$c = ?\ \mathrm{mol/L}$ $\quad c = 4.50\ \mathrm{mmol/L}$

$$c\,H_2SO_4 = 38.93\ \mathrm{mL} \times \frac{4.50\ \mathrm{mmol\ KOH}}{1\ \mathrm{L}} \times \frac{1\ \cancel{\mathrm{mol\ H_2SO_4}}}{2\ \cancel{\mathrm{mol\ KOH}}} \times \frac{1}{25.0\ \mathrm{mL}}$$

$$= 3.50\ \mathrm{mmol/L}$$

30. $Ca(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow CaSO_4(s) + 2NaNO_3(aq)$

$V = 50.0\ \mathrm{mL}$ $\quad V = 200\ \mathrm{mL}$

$c = 0.200\ \mathrm{mol/L}$ $\quad c = 0.180\ \mathrm{mol/L}$

$$n\,Na_2SO_4 = 50.0\ \cancel{\mathrm{mL}} \times \frac{0.200\ \cancel{\mathrm{mol\ Ca(NO_3)_2}}}{1\ \cancel{\mathrm{L}}} \times \frac{1\ \mathrm{mol\ Na_2SO_4}}{1\ \cancel{\mathrm{mol\ Ca(NO_3)_2}}}$$

$$= 10.0\ \mathrm{mmol}$$

.

$$n\,Na_2SO_4\ \text{remaining} = 36.0\ \mathrm{mmol} - 10.0\ \mathrm{mmol}$$

$$= 26.0\ \mathrm{mmol}$$

$$c\,Na_2SO_4 = \frac{26.0\ \mathrm{mmol}}{250\ \mathrm{mL}} = 0.104\ \mathrm{mol/L}$$

31. $AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$

$V = 25.0$ mL $\qquad m = 0.842$ g

$c = ?$ mol/L $\qquad M = 143.32$ g/mol

$$c\,AgNO_3 = 0.842\ \cancel{g\ AgCl} \times \frac{1\ \cancel{mol\ AgCl}}{143.32\ \cancel{g\ AgCl}} \times \frac{1\ \cancel{mol}\ AgNO_3}{1\ \cancel{mol\ AgCl}} \times \frac{1}{25.0\ \cancel{mL}} \times \frac{1000\ \cancel{mL}}{1\ L}$$

$$= 0.235 \text{ mol/L}$$

32. $S_8(s) + 12O_2(g) + 8H_2O(\ell) \rightarrow 8H_2SO_4(\ell)$

$m = 1.00$ kg $\qquad m = ?$ g

$M = 256.56$ g/mol $\qquad M = 98.09$ g/mol

$$m\,H_2SO_4 = 1.00 \text{ kg } S_8 \times \frac{1\ \cancel{mol\ S_8}}{256.56\ \cancel{g\ S_8}} \times \frac{8\ \cancel{mol\ H_2SO_4}}{1\ \cancel{mol\ S_8}} \times \frac{98.09\ \cancel{g\ H_2SO_4}}{1\ \cancel{mol\ H_2SO_4}}$$

$$= 3.06 \text{ kg}$$

33. **(a)** $P_4S_3\,(g) + 8O_2(g) \rightarrow P_4O_{10}(g) + 3SO_2(g)$

(b) $$V = 5.3\ \cancel{L\ O_2}(g) \times \frac{3\ \cancel{L}\ SO_2\ (g)}{8\ \cancel{L}\ O_2\ (g)} = 2.0 \text{ L } SO_2\ (g)$$

(c) $$m = \frac{5.3\ \cancel{L\ O_2(g)}}{22.4\ L/\cancel{mol\ O_2(g)}} \times \frac{1\ \cancel{mol\ P_4S_3(s)}}{8\ \cancel{mol\ O_2(g)}} \times \frac{220.09\ g\ P_4S_3(s)}{1\ \cancel{mol\ P_4S_3(s)}}$$

$$= 6.5 \text{ g } P_4S_3(s)$$

34. $3CH_4(g) + 6H_2O(\ell) + 4N_2(g) \rightarrow 8NH_3(g) + 3CO_2(g)$

$m = 1000$ kg $\qquad V = ?$ L

$M = 16.05$ g/mol $\qquad T = 300$ K

$P = 100$ kPa

(a) $V\,NH_3 = 1000\ \cancel{kg\ CH_4} \times \dfrac{1\ \cancel{mol\ CH_4}}{16.05\ \cancel{g\ CH_4}} \times \dfrac{8\ \cancel{mol\ NH_3}}{3\ \cancel{mol\ CH_4}} \times \dfrac{8.314\ \cancel{kPa}\cdot L/mol\cdot\cancel{K} \times 300\ \cancel{K}}{100\ \cancel{kPa}}$

$= 4.15 \times 10^6\ L$

(b) $m\,NH_3 = 1000\ kg\ CH_4 \times \dfrac{1\ \cancel{mol\ CH_4}}{16.05\ g\ CH_4} \times \dfrac{8\ \cancel{mol\ NH_3}}{3\ \cancel{mol\ CH_4}} \times \dfrac{17.04\ \cancel{g\ NH_3}}{1\ \cancel{mol\ NH_3}}$

$= 2831\ kg$

(c) $V = 2831\ kg \times \dfrac{m^3}{681.91\ kg} = 4.15\ m^3$

35. $C_9H_8O_4(aq) + NaOH(aq) \rightarrow NaC_9H_7O_4(aq) + H_2O(\ell)$

$m = ?\ g$ $\quad V = 13.4\ mL$

$M = 180.17\ g/mol$ $\quad c = 0.132\ mol/L$

(a) $m\,C_9H_8O_4 = 13.4\ \cancel{mL} \times \dfrac{0.132\ \cancel{mol\ NaOH}}{1\ \cancel{L}} \times \dfrac{1\ \cancel{mol\ C_9H_8O_4}}{1\ \cancel{mol\ NaOH}} \times \dfrac{180.17\ g\ C_9H_8O_4}{1\ \cancel{mol\ C_9H_8O_4}}$

$= 319\ mg$

(b) $\%\ Yield = \dfrac{319\ mg}{325\ mg} \times 100 = 98.2\%$

(c) A small piece of the tablet could have broken off due to the tablets bumping against each other and against the bottle.

36. $Ca^{2+}(aq) + 2HF(aq) \rightarrow CaF_2(s) + 2H^+(aq)$

$V = 2.8\ L \qquad V = ?\ L$

$c = 2.5\ mmol/L \qquad c = 1.5\ mol/L$

$$v\,HF = 2.8\ L \times \frac{2.5\ \cancel{mmol\ Ca^{2+}}}{1\ \cancel{L}} \times \frac{2\ \cancel{mol\ HF}}{1\ \cancel{mol\ Ca^{2+}}} \times \frac{1\ \cancel{L}}{1.5\ \cancel{mol\ HF}}$$

$$= 9.3\ mL$$

37. $2C_4H_9SH(\ell) + NaOCl(aq) \rightarrow (C_4H_9)_2S(\ell) + NaCl(aq) + H_2O(\ell)$

$m = ?\ g \qquad V = 5.00\ mL$

$M = 90.21\ g/mol \qquad c = 0.0986\ mol/L$

$$m\,C_4H_9SH = 5.00\ \cancel{mL} \times \frac{0.0986\ \cancel{mol\ NaOCl}}{1\ \cancel{L}} \times \frac{2\ \cancel{mol\ C_4H_9SH}}{1\ \cancel{mol\ NaOCl}} \times \frac{90.21\ g\ C_4H_9SH}{1\ \cancel{mol\ C_4H_9SH}}$$

$$= 88.9\ mg$$

38. $Fe_2O_3(s) + 6H_2C_2O_4(aq) \rightarrow 2Fe(C_2O_4)_3^{3-}(aq) + 3H_2O(\ell) + 6H^+(aq)$

$m = ?\ g \qquad V = 500\ mL$

$M = 159.70\ g/mol \qquad c = 0.11\ g/mol$

$$m\,Fe_2O_3 = 500\ mL \times \frac{0.11\ \cancel{mol\ H_2C_2O_4}}{1\ L\ H_2C_2O_4} \times \frac{1\ \cancel{mol\ Fe_2O_3}}{6\ \cancel{mol\ H_2C_2O_4}} \times \frac{159.70\ g\ Fe_2O_3}{1\ \cancel{mol\ Fe_2O_3}}$$

$$= 1.46\ g$$

Since only 1.0 g of red rust is present, there is more than enough oxalic acid to completely remove it.

39. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$

n = ? mol $\qquad V$ = 27.9 mL

c = 0.250 mol/L $\qquad c$ = 0.230 mol/L

$$n\,H_2SO_4 = 27.9\ \text{mL} \times \frac{0.230\ \text{mol NaOH}}{1\ \text{L}} \times \frac{1\ \text{mol}\ H_2SO_4}{2\ \text{mol NaOH}}$$

$$= 3.21\ \text{mmol remains}$$

$$n\,H_2SO_4\ \text{originally present} = 50.0\ \text{mL} \times \frac{0.250\ \text{mol}\ H_2SO_4}{1\ \text{L}}$$

$$= 12.5\ \text{mmol}$$

$$n\,H_2SO_4\ \text{that reacted} = 12.5\ \text{mmol} - 3.21\ \text{mmol}$$

$$= 9.3\ \text{mmol}$$

$$n\,NH_3 = 9.3\ \text{mmol}\ H_2SO_4 \times \frac{2\ \text{mol}\ NH_3}{1\ \text{mol}\ H_2SO_4}$$

$$= 18.6\ \text{mmol}$$

$$n\,(NH_4)_2SO_4 = 18.6\ \text{mmol NH}_3 \times \frac{1\ \text{mol}\ (NH_4)_2SO_4}{2\ \text{mol NH}_3}$$

$$= 9.3\ \text{mmol}$$

$$m\,(NH_4)_2SO_4 = 9.3\ \text{mmol}\ (NH_4)_2SO_4 \times \frac{132.17\ \text{g}\ (NH_4)_2SO_4}{1\ \text{mol}\ (NH_4)_2SO_4}$$

$$= 1.23\ \text{g}$$

percentage = (1.23 g / 10.0 g) × 100 = 12.3%

40. (a) 7.32 g $H_2O(g)$

Complete Solution

$$n_{SiO_2(s)} = \frac{m_{SiO_2(s)}}{M_{SiO_2(s)}}$$

$$= \frac{12.2 \text{ g } SiO_2(s)}{60.09 \frac{\text{g } SiO_2(s)}{\text{mol } SiO_2(s)}}$$

$$= 0.203 \text{ mol } SiO_2(s)$$

$$n_{H_2O(g)} = 0.203 \text{ mol } SiO_2(s) \times \frac{2 \text{ mol } H_2O(g)}{1 \text{ mol } SiO_2(s)}$$

$$= 0.406 \text{ mol } H_2O(g)$$

$$m_{H_2O(g)} = n_{H_2O(g)} M_{H_2O(g)}$$

$$= 0.406 \text{ mol } H_2O(g) \times \frac{18.02 \text{ g } H_2O(g)}{1 \text{ mol } H_2O(g)}$$

$$= 7.32 \text{ g } H_2O(g)$$

(b) 34.2% yield

Complete Solution

$$\text{percentage yield} = \frac{\text{experimental yield}}{\text{predicted yield}} \times 100\%$$

$$= \frac{2.50 \text{ g}}{7.32 \text{ g}} \times 100\%$$

$$= 34.2\% \text{ yield}$$

Complete Solution

$$n_{H_2O(g)} = \frac{m_{H_2O(g)}}{M_{H_2O(g)}}$$

$$= \frac{2.50 \text{ g } H_2O(g)}{18.02 \dfrac{\text{g } H_2O(g)}{\text{mol } H_2O(g)}}$$

$$= 0.139 \text{ mol } H_2O(g)$$

$$n_{SiF_4(s)} = 0.139 \text{ mol } H_2O(g) \times \frac{1 \text{ mol } SIF_4(s)}{2 \text{ mol } H_2O(g)}$$

$$= 0.0694 \text{ mol } SIF_4(s)$$

$$m_{SiF_4(s)} = n_{SiF_4(s)} M_{SiF_4(s)}$$

$$= 0.694 \text{ mol } SIF_4(s) \times \frac{104.09 \text{ g } SIF_4(s)}{1 \text{ mol } SIF_4(s)}$$

$$= 7.22 \text{ g } SIF_4(s)$$

41. 36.6% yield

Complete Solution

$$n_{Na_2SO_4(s)} = \frac{m_{Na_2SO_4(s)}}{M_{Na_2SO_4(s)}}$$

$$= \frac{4.36 \text{ g } Na_2SO_4(s)}{142.05 \dfrac{\text{g } Na_2SO_4(s)}{\text{mol } Na_2SO_4(s)}}$$

$$= 0.0307 \text{ mol } Na_2SO_4(s)$$

$$n_{SiF_4(s)} = 0.0307 \text{ mol } Na_2SO_4(s) \times \frac{1 \text{ mol } BaSO_4(s)}{1 \text{ mol } Na_2SO_4(s)}$$

$$= 0.0307 \text{ mol } BaSO_4(s)$$

$$m_{SiF_4(s)} = n_{SiF_4(s)} M_{SiF_4(s)}$$

$$= 0.0307 \text{ mol } BaSO_4(s) \times \frac{233.40 \text{ g}}{1 \text{ mol } BaSO_4(s)}$$

$$= 7.16 \text{ g } BaSO_4(s)$$

$$\text{percentage yield} = \frac{\text{experimental yield}}{\text{predicted yield}} \times 100\%$$

$$= \frac{2.62\ \text{g}}{7.16\ \text{g}} \times 100\%$$

$$= 36.6\%\ \text{yield}$$

42. (a) 15.1 g $C_6H_5Br(\ell)$

$$n_{C_6H_6(\ell)} = \frac{m_{C_6H_6(\ell)}}{M_{C_6H_6(\ell)}}$$

$$= \frac{7.50\ \text{g}\ C_6H_6(\ell)}{\frac{78.12\text{g}\ C_6H_6(\ell)}{\text{mol}\ C_6H_6(\ell)}}$$

$$= 0.0960\ \text{mol}\ C_6H_6(\ell)$$

$$n_{C_6H_5Br(\ell)} = 0.0960\ \text{mol}\ C_6H_6(\ell) \times \frac{1\ \text{mol}\ C_6H_5Br(\ell)}{1\ \text{mol}\ C_6H_6(\ell)}$$

$$= 0.0960\ \text{mol}\ C_6H_5Br(\ell)$$

$$m_{C_6H_5Br(\ell)} = n_{C_6H_5Br(\ell)} M_{C_6H_5Br(\ell)}$$

$$= 0.0960\ \text{mol}\ C_6H_5Br(\ell) \times \frac{157.01\ \text{g}\ C_6H_5Br(\ell)}{1\ \text{mol}\ C_6H_5Br(\ell)}$$

$$= 15.1\ \text{g}\ C_6H_5Br(\ell)$$

(b) 0.414 g

Complete Solution

$$n_{C_6H_4Br_2(\ell)} = \frac{m_{C6H4Br2(\ell)}}{M_{C6H4Br2(\ell)}}$$

$$= \frac{1.25\ \text{g}\ C_6H_4Br_2(\ell)}{235.9\frac{\text{g}\ C_6H_4Br_2(\ell)}{\text{mol}\ C_6H_4Br_2(\ell)}}$$

$$= 0.00530\ \text{mol}\ C_6H_4Br_2(\ell)$$

$$n_{C_6H_6(\ell)} = 0.00530 \text{ mol } C_6H_4Br_2(\ell) \times \frac{1 \text{ mol } C_6H_6(\ell)}{1 \text{ mol } C_6H_4Br_2(\ell)}$$
$$= 0.00530 \text{ mol } C_6H_6(\ell)$$

$$m_{C_6H_6(\ell)} = n_{C_6H_6(\ell)} M_{C_6H_6(\ell)}$$
$$= 0.00530 \text{ mol } C_6H_6(\ell) \times \frac{78.12 \text{ g } C_6H_6(\ell)}{1 \text{ mol } C_6H_6(\ell)}$$
$$= 0.414 \text{ g } C_6H_6(\ell)$$

(c) 14.2 g of bromobenzene were formed.

(d) The yield was 94.5 %.

Answers to Making Connections Questions

43. The words "air bags" and "airbags" in a Google search bring up a number of excellent resources for high school students. Most of the entries list the pros for the use of air bags, but some sites do investigate the cons. These sites also describe the specific conditions in which air bags should not be used. A number of questionable sites, lacking scientific basis, also appeared in the search. Discuss the difference between reputable sources (e.g., Canadian Safety Council) and less reputable sources (e.g., joe'swebpage.com) and how to use internet resources judiciously.

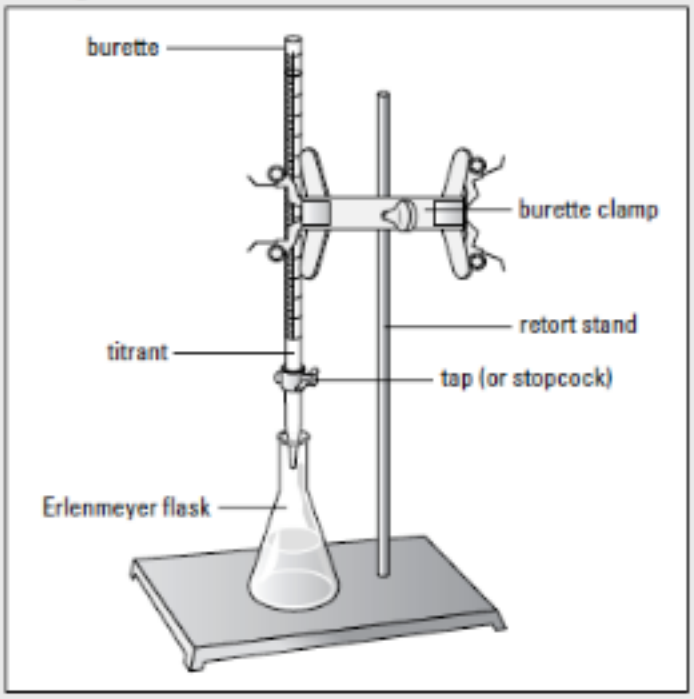
Pros

- deaths from impact injuries in collisions are reduced
- injuries due to automobile accidents are reduced
- health care costs due to automobile accidents are reduced

Cons

- driver and passenger must be properly seated in car (proper distance from front of car)
- small children cannot be in the front seat with an airbag
- rear-facing infant seats cannot be used with an air bag
- air bags may cause injury

Diagram:



Sample Calculation:

From the four trials, average the volume of base required to reach equivalence point. This is the volume of base.

A sample balanced equation is shown below.

$$2NaOH(aq) + H_2C_6H_6O_6(aq) \rightarrow Na_2C_6H_6O_6(aq) + 2H_2O(\ell)$$

$$n_{NaOH(aq)} = c_{NaOH(aq)} \times V_{NaOH(aq)}$$
$$= nNaOH(aq)$$

$$n_{H_2C_6H_6O_6(aq)} = nNaOH(aq) \times \frac{1 \text{ mol } H_2C_6H_6O_6(aq)}{2 \text{ mol } NaOH(aq)}$$

$$= nH_2C_6H_6O_6(aq)$$

$$c_{H_2C_6H_6O_6(aq)} = \frac{n_{H_2C_6H_6O_6(aq)}}{V_{H_2C_6H_6O_6(aq)}}$$

$$= \frac{nH_2C_6H_6O_6(aq)}{0.250 \text{ L}}$$

$$= cH_2C_6H_6O_6(aq)$$